CLIP ON MANIFOLD HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of U.S. patent application Ser. No. 09/411,295 filed Oct. 4, 1999.

BACKGROUND OF THE INVENTION

This invention relates to heat exchangers, and in particular, to plate and fin type heat exchangers such as the type used with internal combustion engines for cooling engine coolant.

In the past, engine coolant heat exchangers, such as radiators, have been made by providing a plurality of parallel, spaced-apart flat tubes with cooling fins located therebetween to form a core. Opposed ends of the tubes pass through openings formed in manifolds or headers located on each side of the core at the respective ends of the tubes. A difficulty with this type of construction is that the tube to headerjoints are difficult to fabricate and prone to leakage.

A method of overcoming these difficulties is shown in U.S. Pat. No. 3,265,126 issued to D. M. Donaldson. In this patent, headers are provided with a continuous longitudinal opening, and the tubes are formed with specially shaped ends to fit into this continuous opening, thus simplifying the assembly and reducing the leakage problem. A difficulty with the Donaldson structure, however, is that the shape of the various components is quite complex resulting in high tooling costs.

The present invention is a heat exchanger of universal application where relatively simple and inexpensive tooling is required to make heat exchangers of different types and even with differing sizes and configurations.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a heat exchanger comprising a plurality of stacked plate pairs formed of mating plates having central planar portions and raised peripheral edge portions. The edge portions are joined together in mating plates to define a flow channel between the plates. The plates have offset end flanges, the respective flanges at each end of each plate pair diverging. The flanges have lateral edge portions extending from root areas located at the joined peripheral edge portions. The end flanges also have transverse distal edge portions joined together in back-to-back stacked plate pairs to space the plate pairs apart and form transverse flow passages between the plate pairs. Opposed U-shaped channels enclose the respective end flanges of the plate pairs. The channels have rear walls spaced from the plate end flanges and side walls joined to the flange lateral edge portions covering the root areas. The U-shaped channels have open ends. End plates close the U-shaped channel open ends to form manifolds. Also, the manifolds define inlet and outlet openings therein for the flow of fluid through the plate pairs.

According to another aspect of the invention, there is provided a method of making a heat exchanger comprising the steps of providing an elongate strip of plate material having a planar central portion and raised peripheral edge portions. The plate material is cut into predetermined lengths. The plate lengths are formed with offset end flanges extending in a direction away from the peripheral edge portions. The plate lengths are arranged into plate pairs with the offset end flanges diverging and the plate peripheral edge portions in contact. The plate pairs are stacked so that the

end flanges engage to space the plate pairs apart. U-shaped channels are provided to enclose the plate offset end flanges, the channels having open ends. The channel open ends are closed to form manifolds, and inlet and outlet openings are formed in the manifolds. The plates and manifolds are joined together to form a sealed heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is a top, left perspective view of a preferred embodiment of a heat exchanger made in accordance with the present invention;

FIG. **2** is a bottom left perspective view of the lower corner of the heat exchanger shown in FIG. **1** as viewed in the direction of arrow **2**;

FIG. **3** is an enlarged perspective view taken in the direction of arrow **3** of FIG. **1** showing a portion of the heat exchanger of FIG. **1** being assembled;

FIG. **4** is a plan view taken along lines **4**—**4** of FIG. **3**;

FIG. **5** is an enlarged scrap view of the area of FIG. **4** indicated by circle **5**;

FIG. **6** is a plan view similar to FIG. **4** showing the addition of a baffle in one of the manifolds;

FIG. **7** is a plan view similar to FIGS. **4** and **6** but showing another preferred embodiment of the present invention;

FIG. **8** is a vertical sectional view taken along lines **8**—**8** of FIG. **6** showing various types of baffles that could be used in the manifolds of the present invention;

FIG. **9** is a plan view similar to FIG. **4** but showing another preferred embodiment of the invention;

FIG. **10** is a plan view similar to FIGS. **4** and **9**, but showing a modification to the embodiment of FIG. **9**;

FIG. **11** is a plan view similar to FIG. **4**, but showing a modification to the flange extensions;

FIG. **12** is a vertical sectional view taken along lines **12**—**12** of FIG. **11**;

FIG. **13** is a vertical sectional view similar to FIG. **12** but showing a modified form of flange extension;

FIG. **14** is a bottom left perspective view of similar to FIG. **2** but showing a modification for locking the plate pairs together;

FIG. **15** is a top, left perspective view of another preferred embodiment of a heat exchanger made in accordance with the present invention;

FIG. **16** is an enlarged vertical sectional view taken along lines **16**—**16** of FIG. **15** showing the lower left corner of the heat exchanger of FIG. **15**; and

FIG. **17** is a bottom left perspective view similar to FIG. **2** but showing another preferred embodiment of an end bracket.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring firstly to FIG. **1**, a preferred embodiment of a heat exchanger according to the present invention is generally indicated by reference numeral **10**. Heat exchanger **10** is in the form of a radiator for cooling the coolant of an internal combustion engine, such as is typically found in an automotive vehicle. Heat exchanger **10** includes a filler cap **12** mounted in a suitable fitting **14** having an overflow or pressure relief outlet **16**. Heat exchanger **10** has a core **18**

formed of a plurality of spaced-apart plate pairs 20 with cooling fins 22 located therebetween. Cooling fins 22 are the usual type of corrugated cooling fins having transverse undulations or louvres 24 formed therein to increase heat transfer (see FIGS. 3 and 8). Any type of cooling fin could be used in the present invention, or even no cooling fin at all, if desired.

Heat exchanger 10 has a pair of manifolds 26, 28 located at the respective ends of plate pairs 20. Inlet and outlet nipples or fittings 30, 32 are mounted in one of the manifolds 26, 28 for the flow of coolant into and out of heat exchanger 10, as will be described further below. An optional temperature sensor 34 can also be mounted in one of the manifolds 26, 28 to sense the temperature of the coolant inside heat exchanger 10.

A top end plate 36 closes the upper ends of manifolds 26, 28 and provides a location for mounting the filler cap fitting 14 and also a bracket 38 for mounting heat exchanger 10 in a desired located. A bottom end plate 40 is also provided to close the lower ends of manifolds 26, 28 and provide a location for the attachment of another mounting bracket 42 for mounting heat exchanger 10 in a desired location. If desired, filler cap 12 could be mounted in or attached to the walls of either manifold 26 or 28 instead of end plate 36.

Referring next to FIGS. 3 and 8, plate pairs 20 are formed of top and bottom mating plates 44, 46. Each plate 44, 46 has a central planar portion 48 and raised peripheral edge portions 50, 52, so that when the plates 44, 46 are put together face-to-face, the peripheral edge portions 50, 52 are joined together and the planar central portions 48 are spaced apart to define a flow channel 54 (see FIG. 8) between the plates.

As seen best in FIGS. 3 and 8, plates 44, 46 have offset end flanges 56, 58. The respective end flanges 56, 58 at each end of each plate pair 20 diverge from a root area 60 where the raised peripheral edge portions 50, 52 are still joined together, to transverse distal edge portions or flange extensions 62. The offset end flanges 58 also have lateral edge portions 64 that extend from root areas 60 to transverse distal edge portions 62. It will be noted that transverse distal edge portions or flange extensions 62 are joined together in back-to-back stacked plate pairs 20. This spaces the plate pairs 20 apart to provide transverse flow passages 66 between the plate pairs where cooling fins 22 are located.

Manifolds 26, 28 are formed of opposed, U-shaped channels having rear walls spaced from the plate offset end flanges 56, 58, and side walls 70, 72 joined to the flange lateral edge portions 64. The channel side walls 70, 72 actually cover the root areas 60 where the peripheral flanges 50,52 are still joined together, and since the lateral edge portions 64 of offset end flanges 56, 58 are joined to the inside walls of channel side walls 70, 72, a fluid tight seal is provided, so that fluid inside manifolds 26, 28 can only flow through the flow channels 54 inside plate pairs 20.

The U-shaped channels or manifolds 26, 28 are formed from folded or formed aluminum sheet or an alumninum extrusion cut to a desired length and thus have open ends 74. Top end plate 36 closes the open ends 74 at the top of manifolds 26,28 and bottom end plate 40 closes the bottom open ends 74 of manifolds 26,28. As seen best in FIGS. 2 and 8, bottom end plate 40 also has offset end flanges 76 that fit snugly inside the U-shaped channels or manifolds 26 and 28 and engage the flange extension 62 formed on the adjacent bottom plate 46. Bottom end plate 40 is actually an inverted U-shaped member having side skirts 78 with distal extensions 80 that wrap around manifolds 26, 28 to help hold heat exchanger 10 together during assembly. If desired, top end plate 36 could be the same configuration as bottom end plate 40.

It will be appreciated that U-shaped manifolds 26, 28 could have other cross-sectional configurations, such as trapezoidal, or hemispheroidal. For the purposes of this disclosure, the term "U-shaped" is intended to include any cross-sectional configuration that is capable of enclosing offset end flanges 56, 58.

Referring next to FIGS. 3 to 5, it will be seen that raised peripheral edge portions 50, 52 are formed with fingers 82 spaced from the flange lateral edge portions 64 to define slots 84 to accommodate the U-shaped channel side walls 70, 72. As seen best in FIG. 5, slots 84 are slightly tapered inwardly to urge the U-shaped channel side walls 70,72 into tight engagement with lateral edge portions 64.This provides a snug fit, so that manifolds 26, 28 actually clip on and are retained in position during the assembly of heat exchanger 10. If desired, fingers 82 could be twisted 90 degrees during assembly to help lock the manifold walls 70,72 against lateral edge portions 64. Slots 84 are slightly deeper or longer than the length of side walls 70, 72 that extend into the slots for purpose which will be described further below.

FIG. 6 shows the use of a baffle 86 attached to one of the flange extensions 62 and extending between the U-shaped channel rear wall 68 and side walls 70, 72 to divide manifold 26 into separate compartments above and below baffle 86. Baffle 86 would be used in a location, for example, such as is shown by chain dotted lines 88 in FIG. 1 to divide manifold 26 into a lower compartment 90 communicating with inlet fitting or opening 30, and an upper compartment 92 communicating with outlet fitting or opening 32. In this way, fluid entering inlet 30 would pass through the plate pairs 20 located below baffle 86, enter manifold 28 and flow upwardly to pass back through the plate pairs located above baffle 86 to exit through outlet 32. Baffle 86 could be located at any plate pair between inlet 30 and outlet 32 to balance the cooling inside heat exchanger 10.

FIG. 8 shows various types of baffles that could be used in heat exchanger 10. This is for illustration only, because normally there would only be one baffle used in heat exchanger 10. However, if it were desired to divide heat exchanger 10 into multiple discrete heat exchangers or zones, each having its own inlet and outlet, then any number of baffles could be used to divide up heat exchanger 10 into separate heat exchangers. Also, the baffles could be used selectively in both the manifolds 26, 28 to cause the coolant to flow in a serpentine path through the heat exchanger, if desired.

In FIG. 8, baffles 86, 93, 94 and 95 are shown having bifurcated inner ends to engage the mating flange extensions 62. These bifurcated ends 96 also help hold flange extensions 62 together during assembly of heat exchanger 10. Baffles 86, 94 and 97 also have resilient wall portions 98 to act as springs to ensure a good seal against the U-shaped channel rear wall 68, and to accommodate any movement of the heat exchanger components while they are being joined together, such as by brazing.

FIG. 7 shows another preferred embodiment wherein the plate raised peripheral edge portions 50, 52 are formed with transverse notches 100 instead of slots 84 as in the embodiment of FIG. 6. Notches 100 are located inwardly of but adjacent to the lateral edge portions 64 and root areas 60 where offset end flange 58 start to diverge. Channel side walls 70, 72 are formed with inwardly disposed peripheral flanges 102 that are located in notches 100. Notches 100 are

deeper than flanges 102, and side walls 70, 72 are somewhat resilient, so peripheral flanges 102 snap into notches 100 allowing the U-shaped channels to clip on to the core assembly and lock the assembly together.

Plates 44, 46 in FIG. 7 are also formed with longitudinal, inwardly disposed matching ribs 104 which strengthen the plate pairs and keep the planar central portions 48 from sagging during the brazing process to complete heat exchanger 10. If desired, longitudinal ribs 104 could also be employed in the embodiment shown in FIGS. 2 to 6. Multiple ribs 104 could be provided as well. Also, instead of ribs 104, central portions 48 could be formed with dimples (not shown) that extend inwardly in mating engagement in the plate pairs. Another possibility is to provide flow enhancing turbulizers or turbulators (also not shown) between the plates of the plate pairs 20.

Referring next to FIG. 9, another preferred embodiment of the invention is shown where peripheral edge portions 50,52 are formed with necked-in portions 106 instead of slots 84 as in the embodiment of FIG. 6. Necked-in portions 106 extend inwardly beyond lateral edge portions 64 and root areas 60 where offset end flanges 58 start to diverge, so that channel side walls 70,72 provide a sealed enclosure communicating with the flow passages between the plates of the plate pairs 20.

FIG. 10 is similar to FIG. 9, but shows side walls 70, 72 having outwardly disposed peripheral flanges 108. Flanges 108 provide a surface upon which a fixture can press to urge manifolds inwardly to hold the components of heat exchanger 10 together during the assembly and brazing process.

In the embodiments shown in FIGS. 9 and 10, manifolds 26, 28 are still considered to "clip on" for the purposes of the present invention, since the manifold side walls 70, 72 would be somewhat resilient and would frictionally engage lateral edge portions 64 to hold the manifolds in place, at least during the initial assembly of the components of the heat exchangers of the invention.

FIGS. 11 and 12 show a further modification. which is applicable to any of the embodiments described above. In the FIGS. 11 and 12 embodiment, the transverse distal edge portions or flange extensions 62 are formed with cut-outs or notches 110. Flange extensions 62 can be made with different widths to adjust the low through manifolds 26, 28 and notches 110 can be used to further refine or fine tune the flow patterns inside the manifolds. As seen best in FIG. 12, flange extensions 62 are curved to ensure a good seal therebetween, in case the notches 110 do not line up perfectly in the assembly of heat exchanger 10.

FIG. 13 is a view similar to FIG. 12, but it shows a further modification of flange extensions 62 in that they extend inwardly instead of outwardly as in the previous embodiments. Again, this configuration could be used in any of the embodiments described above. The inwardly directed flanges 62 give the maximum unobstructed flow through manifolds 26, 28.

FIG. 14 is a view similar to FIG. 2, but it shows a modification to end plate 40 where distal extensions 80 have been eliminated. Instead of distal extensions 80 to help hold the heat exchanger components together during the assembly process, manifold rear walls 68 are formed with tabs 112 that are bent over to engage offset end flanges 76 of end plate 40. Tabs 112 help hold the stack of plate pairs 20 together while the heat exchanger is being set up for brazing. If desired, however, both tabs 112 and the distal extensions 80 of the FIG. 2 embodiment could be used together in the same heat exchanger.

Referring next to FIGS. 15 and 16, another preferred embodiment of a heat exchanger 112 is shown, which has top and bottom manifolds 28 and 26 instead of side mounted manifolds as in FIG. 1. In heat exchanger 112, the U-shaped channels or manifolds 26,28 are formed with parallel, U-shaped, inwardly disposed ribs 114,116 adjacent to their ends to accommodate and act as locating guides for the offset end flanges 76 of end plates 40. It will be noted that rib 116 is shorter than rib 114 to accommodate the adjacent plate flange extension 62. The ribs engage and locate the end plates to ensure that good brazing joints are achieved between end plate offset end flanges 76 and manifolds 26,28.

FIGS. 15 and 16 also show some additional optional guide and braze enhancing means for the plate flange extensions 62. One option is to use parallel, inwardly disposed, closely spaced-apart, short ribs 118 to sandwich therebetween the peripheral edges of flange extensions 62. Another option is to use inwardly disposed bosses 120 that appear as dimples from the outside of manifolds 26,28. The bosses could be U-shaped as indicated by U-shaped dimples 122 in FIG. 15 (not shown in FIG. 16). These U-shaped bosses or dimples 122 would be particularly useful where a baffle is employed in manifolds 26,28.

FIG. 16 also shows a couple of other modifications to be preferred embodiments, such as an extended distal flange extension 124 on one of the plates of a plate pair 20. Extended flange extension 124 extends filly between the U-shaped channel or manifold rear and side walls to form a baffle inside manifolds 26,28.

FIG. 16 also shows that lateral or side flanges 126 could be provided on the plate offset end flanges 56,58 to help ensure good brazing joints between end flanges 56,58 and the adjacent walls of the manifolds 26,28. Also shown are transverse, distal, offset flanges 128 that could be added to flange extensions 62 to keep flange extensions 62 straight during the brazing process and help provide good bonds therebetween.

Referring next to FIG. 17, a modification to the end plates is shown where end plate 130 side skirts 78 extend integrally around offset end flange 76 to form a pan type end portion that engages the bottom walls of the manifolds 26,28.

In a typical application, the components of heat exchanger 10 are made of brazing clad aluminum (except for the peripheral components such as fittings 30,32, filler cap and fitting 12, 14 and mounting brackets 38, 42). The brazing clad aluminum for core plates 44, 46 typically have a metal thickness between 0.3 and 1 mm (0.012 and 0.040 inches). End plates 36 and 40 have a thickness between 0.6 and 3 mm (0.024 and 0.120 inches), and baffles 86, 93, 94, 95 and 97 have a thickness between 0.25 and 3 mm (0.010 and 0.120 inches). However, it will be appreciated that materials other than aluminum can be used for the heat exchangers of the present invention, even plastic for some of the components, if desired.

The preferred method of making heat exchanger 10 is to roll form an elongate strip of plate material having planar central portion 48 and raised peripheral edge portions 50, 52. Preferably, the plates are formed of brazing clad aluminum. The plate material is then cut into predetermined lengths to determine the desired width of heat exchanger 10. The ends of the plates are then formed, such as by stamping, to create offset end flanges 58 and either slots 84, notches 100 or necked-in portions 106. The plates are then arranged into plate pairs with the offset end flanges 58 diverging or extending in a direction away from peripheral edge portions 50, 52. The peripheral edge portions 50, 52 are thus engaged